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Does Physical Environment Contribute to Basic Psychological Needs? A Self-Determination Theory Perspective on Learning in the Chemistry Laboratory

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Abstract

The role of motivation and emotions in learning has been extensively studied in recent years; however, research on the role of the physical environment still remains scarce. This study examined the role of the physical environment in the learning process from the perspective of basic psychological needs. Although self-determination theory stresses the role of the social and cultural environment, as yet the role of the physical environment has been unexplored. The study focused on beginning chemistry university students' (n=21) experiences in a chemistry laboratory. The data consisted of focus-group interviews and self-report questionnaires. The results indicate that the physical environment can support or thwart the fulfillment of the basic psychological needs. The usability and functionality of spaces and tools contributed to not just the fluency of the intellectual activity but also to the related emotional experience of oneself acting in a particular environment. The physical environment was a source of procedural facilitation: It complemented and challenged the students' existing skills, contributing to their experiences of autonomy and competence. The everyday successes or struggles in the laboratory built on the students' developing professional identity as well as their sense of belonging to the professional community. This study demonstrates that the design and functionality of the physical environment has a significant role in users' intellectual and emotional functioning. It is essential to utilize psychological and pedagogical knowledge when designing or renovating work and learning environments in order to fully make use of the potential of physical environments as part of human performance.

Keywords: self-determination theory; basic psychological needs; physical environment; learning environment; indoor environment; usability

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1. Introduction

In recent years, the broadening field of research on the role of motivation and emotions in learning has produced important new information on how to optimally arrange the study environment (see e.g. Csíkszentmihályi, 2014; Dweck, 2006; Heikkilä & Lonka, 2006; Heikkilä, Lonka, Nieminen & Niemivirta, 2012; Hidi & Renninger, 2006; Job, Walton, Bernecker & Dweck, 2015; Lindblom-Ylänne & Lonka, 2000; Mälkki, 2010; Ryan & Deci, 2009; Seligman, Ernst, Gillham, Reivich & Linkins, 2009; Tuominen-Soini, Salmela-Aro & Niemivirta, 2008). Strikingly, even though knowledge on the study environment, and especially its social attributes, is vast, knowledge on how the physical environment is related to psychological and pedagogical phenomena as yet remains scarce (Sandström, Sjöblom, Mälkki & Lonka, 2013; Beard 2009, 2012; Lansdale, Parkin, Austin & Baguley, 2011; Lonka, 2012; Woolner, Hall, Higgins, McCaughey & Wall, 2007). Intellectual and emotional functioning is always nested in the physical environment, even when working in virtual learning environments. However, most of the research on physical environment has traditionally focused on minimizing its negative effects on health or determining how individuals interact with the environment on a perceptual level (see e.g. Alfonsi, Capolongo & Buffoli, 2014; Evans, Bullinger & Hygge, 1998; Parsons & Hartig, 2000; Ulrich, 1981), rather than on unveiling the role of the physical environment with regard to cognitive and emotional functioning. This study examines the role of the physical environment in supporting learning and basic psychological needs.

Previous research has indicated that the physical environment is far from irrelevant with regard to intellectual functioning: The design and functionality of the physical environment contribute to physically distributed intelligence (Norman, 1993), stress over safety issues and the cognitive capacity available for higher intellectual functioning such as learning (Sandström, Sjöblom, Mälkki & Lonka, 2013). Being organized in a given way, the physical space also conveys assumptions and ideologies (Beard, 2012; Beard & Price, 2010) e.g. on the activity taking place and, as such, tunes the users into different mental modes and roles (Mälkki, Sjöblom & Lonka, 2014). Thus, similarly to the social environment, the physical environment can be seen as either facilitating learning and well-being or posing a challenge to them. Moreover, of particular interest is the emotional experience related to the activity taking place in a given physical space. This experience may likely bear meaning in the process of forming a relation to the place and, more broadly, of developing one's identity as a professional in a given field.

In modern-day society people spend most of their time in indoor environments, and new multidisciplinary information is needed on how to design these spaces to best support the activity expected to take place in them. Both human resources and physical spaces are valuable and costly resources: Typically around 90% of business operating costs consist of direct or indirect staff costs (Alker et al., 2015), and as to physical spaces, expensive indoor environments need to be used efficiently. At the same time, the industry policy of most Western societies prioritizes innovation. We need to acquire further knowledge on how to facilitate the thriving of the human potential by creating fruitful grounds for it. When designing physical learning spaces, it is essential to not only take into account the most fundamental needs of the students, but also to gain understanding on the relations between the physical surroundings and the more refined psychological processes. These issues are focal in both learning environments and environments dedicated to other purposes, such as work or recreation.

Finally, it is not quite enough to focus on the design and functionality of physical space and tools as such. The use of available premises and equipment is essentially determined by the social practices applied in them; for instance, technology advances learning only through transformed social practices (Hakkarainen, 2009; Paavola, Lipponen & Hakkarainen, 2004). Thus, although in this article we examine the role of the physical environment in the fulfillment of basic psychological needs, we do not assume that it is only a matter of a relation between the individual and the physical environment. Rather, we approach the theme from the perspective that the users' experience of the physical environment is mediated by social practices and culturally shared meanings. In a broader sense, we are approaching the intriguing interplay between the human and the material, as well as the intellectual and the emotional.

2. Theoretical framework

2.1 Basic psychological needs

In this study we approach questions of learning and well-being with regard to the physical learning environment from the perspective of basic psychological needs as laid out by the self-determination theory developed by Deci and Ryan (1985, 2000, 2008; Ryan & Deci 2000, 2009). This is a macro-theory of human motivation, personality development and well-being that focuses especially on volitional behavior and the surrounding conditions that support it (Ryan, 2009).

The theory views all human beings as inherently self-determined, actively evolving organisms, with a natural aspiration for continuous psychological development and growth. However, in order to these propensities to be actualized, the satisfaction of basic psychological needs must be sufficiently supported. According to the theory, the social and cultural environment can support the satisfaction of basic psychological needs and the self-determined behavior to varying degrees. Thus, the process of growth is essentially seen to take place in relation to the surrounding conditions that, for their part, contribute to the individuals' possibilities to embrace their full, natural potential. Aligned with this emphasis, it is also relevant to study in more detail how the physical environment may, for its part, contribute to the interaction between the individual and the environment and the fulfilment of basic psychological needs (E. Deci, personal communication with the first author, October 28, 2014).

Self-determination theory is currently one of the most prevalent and utilized theories on motivation. In the decades following the formal introduction of the theory in the 1980s, research on the theory has dramatically increased. Consequently, the theory has been subject to criticisms and suggestions for further development as well. A common criticism of the theory is its cultural applicability, posing that the core features of the theory, such as the need for autonomy, are mainly descriptive of a Western individual, rather than of people raised in and surrounded by more collectivist cultures (e.g. Iyengar & DeVoe, 2003; Markus & Kitayama, 1991). However, further research has verified that psychological needs are equally imperative with regard to psychological well-being in both individualistic and collectivist cultures (e.g. Chirkov, Ryan, Kim & Kaplan, 2003; Ryan & Deci, 2006).

The formal framework of self-determination theory consists of five mini-theories (Ryan, 2009). This study focuses on the mini-theory of basic psychological needs. The theory states that all people, universally and regardless of their age or gender, share the same basic psychological needs, namely the needs for autonomy, competence and relatedness. These needs are seen to be central prerequisites with regard to healthy human functioning.

Autonomy refers to perceiving oneself as the origin or source for one's own behavior (Deci & Ryan, 1985; Ryan & Connell, 1989; Ryan & Deci, 2002, 2006), competence refers to a felt sense of confidence and effectance in one's own actions (Ryan & Deci, 2002), and relatedness refers to feeling connected and having a sense of belonging with regard to both other individuals and with one's community (Baumeister & Leary, 1995; Ryan, 1995; Ryan & Deci, 2002). In order to function effectively and to be psychologically healthy, these needs must be sufficiently satisfied (Deci & Ryan, 2008).

More specifically, the satisfaction of basic psychological needs is relative to the activity and functioning pursued; needs may be seen to specify necessary nutriments with regard to healthy development and vitality as well as constructive and creative outputs (Deci & Ryan, 2002). Thus, rather than being a goal in itself, the satisfaction of basic psychological needs is seen to facilitate intrinsic motivation, learning and well-being (Niemiec & Ryan, 2009; Ryan & Deci, 2009) as well as eudaimonic happiness (Ryan, Huta & Deci, 2008).

The theory of basic psychological needs is widely studied empirically, including in the context of learning in higher education (see e.g. Black & Deci, 2000). In particular, the need for autonomy and the possibilities to support it have acquired much needed attention in the context of learning and instruction (see

e.g. Jang, Reeve & Deci, 2010; Niemiec & Ryan, 2009; Soenens, Sierens, Vansteenkiste, Goossens & Dochy, 2012; Vansteenkiste et al., 2012). However, the research has predominantly focused on the social aspects of the learning environment, such as the interaction between the students and the teacher, while the research on the psychological needs of an individual with regard to the physical environment has been extremely scarce (see e.g. Gay, 2008; Gay, Saunders, & Dowda, 2011; Rutten, Boen & Seghers, 2012).

2.2 The learning environment

Similarly to the research on the basic psychological needs, research on learning environments has mainly focused on the social learning environment while the physical learning environment has for the most part been ignored. For example, Lave and Wenger's idea of legitimate peripheral participation (1991) places high importance on social engagements that provide the proper context for learning to take place. By participating in the activities of an expert community, a novice is gradually able to assimilate the professional practices and become part of the community. These kinds of views stress the role of the social learning environment in the development of professional abilities, yet neglect the physical environments in which the social activity takes place.

Empirical research on physical environments, on the other hand, has traditionally focused on factors related to physical health or discomfort (e.g. Küller & Lindsten, 1992; Winterbottom & Wilkins, 2009). Knowledge on how the physical environment, i.e. physical spaces, tools and equipment, is related to psychological and pedagogical phenomena is still rare (Lansdale, Parkin, Austin & Baguley, 2011; Lonka, 2012; Woolner, Hall, Higgins, McCaughey & Wall, 2007). While the importance of individual characteristics and the social environment should not be underestimated (e.g. Perry, Turner & Meyer, 2006), the role of the physical environment in the learning process calls for more rigorous attention in the field of learning research. More knowledge is needed on how the physical environment can support learning, well-being, engagement and commitment.

Research on learning environments has shown that the physical environment conveys assumptions (Beard, 2012; Beard & Price, 2010) and activates students' previous assumptions regarding similar environments (Mälkki, Sjöblom & Lonka, 2014). The assumptions conveyed by the physical environment may involve underlying conceptions on the learning process and the roles of the participants: An auditorium implies a different positioning and division of roles than a classroom where the desks are organized in groups and the teacher has no central position but is instead moving around the classroom on a chair. This demonstrates how the physical space itself tunes the students into different mental modes and roles. The arrangement of physical space in ways that the participants are not used to may as such turn into a disorienting dilemma, challenging existing conceptions and ways of thinking and possibly triggering reflection (Mälkki, Sjöblom & Lonka, 2014). Thus, the space or equipment cannot be seen as a separate entity, detached from the present culture. Rather, social practices are embedded in the physical arrangements (Hakkarainen, 2009) and also have an impact on how the physical environment is perceived and experienced by the users.

Along with the idea of socially and physically distributed cognition (Hakkarainen, Palonen, Paavola & Lehtinen, 2004; Hutchins, 2000, 2006), physical environments also vary with regard to the degree they facilitate the activity that is expected to take place in them. For example, the space may be equipped with modern technology and devices that assist the learning process, which makes the learning process markedly different from one that is carried out without any needed assistance, such as calculators, to begin with. The very fact that learners are able to choose a suitable environment for different learning tasks is helpful with regard to completing the tasks. A concrete example of this might be having to work on a group assignment in a silent library hall or endeavoring to understand new theoretical material in a noisy hallway.

In fact, the physical environment consists of affordances that may, at best, facilitate the development of new skills, help people overcome the limitations of their own capabilities and make them feel like active agents; or in contrast, the lack of needed affordances may pose a significant challenge to carrying out the

expected activities, handicapping the cognitive functioning in the space and making people feel incapable of performing the expected tasks (Sandström, Sjöblom, Mälkki & Lonka, 2013; Norman, 1993; Sandström, Eriksson, Lonka & Nenonen, 2015). Thus, the physical environment for its part offers a varying degree of procedural facilitation (Bereiter & Scardamalia, 1987) of the aspired activity. If for instance students lack enough space for their work or constantly have to worry about unclear safety issues, these issues inevitably take a toll on the cognitive resources available for learning (Sandström, Sjöblom, Mälkki & Lonka, 2013; see also Sandström, Ketonen & Lonka, 2014). Thus, a dysfunctional environment may be handicapping with regard to intellectual activity at the most basic level. Consequently, we postulate that the design and the functionality of the physical environment play a role in the students' experiences related to the basic psychological needs.

2.3 The context of the study: exploring the basic psychological needs in a chemistry laboratory learning environment

In our study we focus on beginning university chemistry students' learning, in particular on their experiences during laboratory work, in order to unveil the dynamics between physical environment and basic psychological needs. Chemistry as a study context offers an intriguing and relevant terrain for researching this interplay. Namely, the physical laboratory environment, which includes not only desks and chairs but also the diverse and complex laboratory instrumentation, is especially focal in learning chemistry. Focusing on the experiences of first-year students is fruitful from the perspective of their emerging sense of relatedness to the professional field. Furthermore, sense of autonomy and competence are expected to develop in a study context, which, similarly to a working environment, represents a performance-oriented environment. In addition, the aforementioned topics may be particularly present in the students' experiences in the beginning stage of their studies.

As argued earlier in the text, current research on basic psychological needs in study contexts has focused especially on students' sense of autonomy. This is a central question as a study context has traditionally been an environment where the action to a large extent is guided by the teacher, while at the same time, the students have the need to develop their sense of autonomy and competence in the field. This need for a constructive friction between the students' existing capabilities and an appropriate amount of guidance provided by the teacher has also been addressed by Vermunt and Verloop (1999).

In our view, it is important to look more closely at the emerging sense of relatedness with regard to the study community and the physical premises, and more generally, to the professional field. In the chemistry context this may have particular importance: For example, in Finland many students discontinue their chemistry studies after a year or two. For some of these students, this may be due to a transfer to pursue studies in the faculty of medicine, where the chemistry studies serve as a platform to develop the abilities needed to be accepted into that faculty. However, this is not the case for all of the students who drop out of their chemistry studies.

In order to increase understanding on student experiences in the chemistry learning context, it is particularly interesting to examine the role of the physical learning environment from the viewpoint of psychological needs and the support the physical environment could offer for learning. What are the most central characteristics of the physical environment that contribute to emerging experiences of competence, autonomy and relatedness? If we are able to consider the psychological needs of the students when designing learning spaces, we can create a fruitful ground for thriving, productive students and, at best, further current understanding on how to design leading university campuses (Lonka, 2012; Nenonen, Kärnä, Junnonen, Tähtinen & Sandström, 2015).

3. The aims of the study

This study explored the role of the physical environment with regard to learning from the perspective of basic psychological needs. The research questions were as follows: 1. What is the role of the physical environment in the experience of the basic psychological needs? 2. What is the role of the physical environment in the learning process from the perspective of the basic psychological needs?

Aligned with the theory of basic psychological needs, we postulated that the satisfaction of these needs is not a goal as such, but rather a facilitator with regard to productivity and well-being. Consequently, it was relevant to study the experience of the basic psychological needs in relation to the activity pursued, that is, learning. We hypothesized that if the physical environment contributes to the experience of basic psychological needs, this may have a mediating effect on the process of learning; by supporting the fulfillment of basic psychological needs, the physical environment may facilitate learning and study engagement.

In addition, we aimed at furthering the interactional perspective of the theory of basic psychological needs by considering the role of the physical environment in facilitating or posing a challenge to the fulfillment of the core needs. Rather than focusing on individual experiences regarding the core needs, our emphasis was on exploring the dynamics of the phenomenon on a more theoretical level. In order to capture the diversity and depth of the student's experiences regarding this fairly new research topic, the study approached the relations between the physical environment and basic psychological needs with qualitative methodology. While much of the research on motivation is based on self-report questionnaires in order to measure individuals' views and beliefs, classroom observations and interviews can provide a richer depiction of situated motivation (Wigfield, Cambria & Eccles, 2012).

4. Method

4.1 Participants

The participants of the study were beginning-stage chemistry students (n=21, representing both genders) from a Finnish university. The participants were selected based on their willingness to participate as well as the appropriate timing of their current laboratory project; in other words, participation in the interview and selection for a particular focus group also depended on whether they were able to leave their laboratory work for an hour to complete the interview.

4.2 Materials

The data consists of focus group interviews and questionnaires that were completed by each participant individually before entering the interview. The questionnaire served as an orientation to the interview, whereas the qualitative analysis is based on the material from the focus group interviews.

The questionnaire included both open-ended and multiple choice questions. The themes of the questionnaire focused on helpful and challenging aspects of the physical environment with regard to learning as well as typical study-related use of physical spaces, equipment and technological devices:

a) Sources of interest and engagement in the laboratory work (open-ended),
b) Sources of challenge and difficulty in the laboratory work (open-ended),
c) Typical study-related use of technological tools in learning (multiple choice questions assessing the frequency of the use on a scale 1-6; e.g. smartphone, laptop),

d) Typical study-related use of spaces in learning (multiple choice questions assessing the frequency of the use on a scale 1-6; e.g. library, hallways, cafeterias, home),
e) Concrete tools, equipment or other aspects of the laboratory work that are experienced as particularly well-functioning or engaging (open-ended),
f) Concrete tools, equipment or other aspects of the laboratory work that are experienced as particularly cumbersome or counterproductive with regard to learning (open-ended),
g) Other comments and suggestions with regard to the physical learning environment (open-ended).

The interview elaborated on the same questions with the group.

4.3 Procedures

4.3.1 Interviews

Semi-structured focus-group interviews in groups of three to four students were collaboratively carried out by two of the authors. The interviews were conducted contextually in the middle of a laboratory work session. The students completed the questionnaires in the actual laboratory space, an organic chemistry laboratory, and the interviews were carried out in an adjoining room in order to ensure privacy and focused environment. By having the students complete the questionnaire individually before entering the interview, we aimed at giving the students the space to reflect on the topics based on their own experience and perspective first, and the views could then be elaborated further in the group.

The interviews followed an interpretivist approach (Scott & Usher, 1999; Williams, 2000), aiming at "making sense of actor's actions and language within their 'natural' setting" (Williams, 2000). The method of the interview was designed to leave space for the participants to freely discuss themes that they experienced as important.

As the topic of the research is rather new, the structure of the questionnaire and the interview had to be open enough not to restrict the participants but to genuinely leave space for unexpected material and directions, regardless of the preconceptions or hypotheses of the researchers. Moreover, the phenomena and the related experiences are such that a clearly articulated view from the students is hardly expected; rather, the data had to be approached in a holistic way to seek understanding on the phenomena. Thus, the questions were formed rather open so that the interview and the discussion in the groups could develop the topics further. As a result, the interview data brought about a rich milieu of aspects of the students' experiences, beyond the expected themes and hypotheses.

4.3.2 Analysis

The interviews were transcribed verbatim, and the transcriptions were then analyzed by the authors iteratively with the help of the Atlas TI program. Repeated stages of individual and collaborative analysis were conducted to find central categories and patterns in the reported experiences.

The initial stage of the analysis and classification was data driven in order to capture unforeseen observations and patterns in the data. When the researchers gathered to discuss the initial results of the first round of analysis that each had conducted individually, it was noted that despite the differences in the conceptualizations and terminologies of the classifications among the researchers, many of the central themes and categories fell into the dimensions of basic psychological needs. The results of the first round of analysis supported the theory of basic psychological needs as a relevant theoretical approach through which to frame the findings and acquire further understanding on the role of the physical environment in the learning process. The following rounds of analysis focused on elaborating specifically on this approach with continued iterative individual and collaborative rounds.

Indeed, the theory of basic psychological needs was not yet our framework when collecting data. We aimed at more generally unveiling the role of the physical environment in the learning process. Along with the data-driven analyses and initial findings, we started seeing the relevance of further rounds of analysis from the perspective of basic psychological needs. Consequently, the analysis is by no means exhaustive with regard to the relation between basic psychological needs and the physical environment but rather an opening for research on the topic.

This study was a deepening reanalysis of previously analyzed data (Sandström, Sjöblom, Mälkki & Lonka, 2013) on the chemistry laboratory as a physical learning environment. The previous study shed light on the role of the physical space in the learning process: The physical space may contain guidance implemented in it, and the physical space and its usability contribute to the students' sense of safety, which in turn is crucial when students are expected to engage in demanding cognitive activities. However, early in the initial phases of analysis, it seemed that in addition to the aforementioned findings, the data also offered intriguing perspectives on the dynamics between the physical environment, learning and experiences of oneself as a learner in that given environment, which deserved a deepening reanalysis.

The authors represented different fields of expertise, namely educational psychology, clinical psychology, adult education and linguistics. The analysis aimed at utilizing and building on the diversity of the scholarly backgrounds of the researchers to explore different approaches to the phenomena as well as reach understanding on the core features presented in the data. As with the participants of the study, we aimed at both capturing the individual approaches and views as well as elaborating them further by combining the views and abilities of the whole group collaboratively.

Most of the work on the study was carried out collaboratively, with the team of researchers working on the material and writing the text in the same physical space, which added value to the depth of the analysis, as opposed to each researcher separately adding their own share of expertise to the study (Hakkarainen, Palonen, Paavola & Lehtinen, 2004). Moreover, the researchers altered and modified the physical spaces in which they were working during the research process. Choosing a suitable physical space with the required technological tools to accommodate a given work assignment, for example, a collaborative writing session, brought further understanding on the role of the physical space in the work process itself.

The approach to the current study was abductive by nature; by utilizing the theory in the analysis of the data, we aimed at a deeper understanding of the phenomenon as well as at furthering the theory. Our main focus was on the dynamics between the physical environment and the experiences of the learner rather than on a purely deductive approach driven by an emphasis on testing the theory. From a methodological point of view, our aim was not to cover all possible variations of the interplay between the physical environment and the psychological needs in the context of chemistry studies. Rather, our study was aimed at serving as an opening for research on previously unmapped ground. Even though the sample size can be seen as a limitation of the study and a broader sample could have been advantageous, from a theoretical point of view (see Mälkki, 2012) the data were rich and offered relevant material for an exploratory analysis on the dynamics of the topic.

5. Results

In the following sections we will focus on how the three core needs, autonomy, competence and relatedness (Ryan & Deci, 2002), manifest in relation to the physical environment and the learning context. As our approach stretches the theory of psychological needs out of its usual sphere of application, we employed an abductive approach to be open to dynamics of the phenomenon that are not readily conceptualized in self-determination theory. For analytical clarity, we will in the following first examine each dimension individually, and secondly we will discuss how these dimensions are intertwined in the data.

5.1 Autonomy

5.1.1 Physically mediated guidance and the use of modern technological devices in supporting students' sense of autonomy

Within the context of learning and instruction, the issue of autonomy is often regarded to predominantly concern the balance between the control over one's work and the received guidance, which is usually seen as socially mediated. Students need sufficient guidance and should not be "abandoned," but the teacher should not regulate or perform on behalf of the students the tasks and challenges that they already master, thus disturbing the sense of autonomy experienced by the students.

As for the laboratory as a physical entity, guidance may be seen not merely as socially mediated but also as physically mediated (Sandström, Sjöblom, Mälkki & Lonka, 2013; Hutchins, 2006); information may be embedded in the physical space itself. For instance, different tags and signs can be seen as affordances (Norman, 1993) that assist individual information processing. They help people overcome the boundaries of their intellectual capacities. Thus, the workspace itself can be seen as cognitively structuring, also with regard to the clarity of close surroundings such as desks. Architecturally, the space itself may also communicate information, which is the case, for instance, when signs in a hallway are not needed to locate the corridor to the restrooms.

On the other hand, a lack of needed information or tools provided by the physical environment can reduce one's prerequisites for performing various tasks, either practical or intellectual, in the space. Not only does this happen factually, but this may also challenge the experiences of one's own ability and autonomy, at worst bringing about a sense of inability due to a dysfunctional environment. In this sense, properties of the physical surroundings become incorporated as capabilities of the individual. The information embedded in the physical environment may also reduce the need to seek instructions for tasks on the very basic level of functioning, such as finding the appropriate equipment to perform a given task. In contrast, if a student is not capable of navigating independently in the space without constantly asking for information on the most basic level, this can be harmful not only for the process of learning but also for the sense of autonomy experienced by the student.

In fact, the guidance provided by the physical space itself may be seen as more supportive of the autonomy of the students as they take on a more active role when searching for the needed information from the physical environment, as opposed to being socially given the information that the teacher assumes that they need. They are "the origin or source for one's own behavior" (Deci & Ryan, 1985; Ryan & Deci, 2002), and the more they can autonomously direct their study-related behavior in meaningful ways, the more they themselves are in control of the learning process. For these purposes, the physical environment may provide not only information and guidance, but also tools for searching for the requisite information. For example, the students described their frequent use of modern technology, such as smartphones, tablets and laptops, in searching for relevant information. The use of modern technologies was experienced as handy and quick in comparison to searching for the information from the library. It also seemed that the use of modern technology was at times more supportive of the students' sense of autonomy as it reduced the need to lean on the teacher as a source of information within the laboratory space. However, some students found that the physical space did not accommodate the use of modern tools as well as they would have hoped. The students reported that workspaces crowded with chemical equipment often did not leave room for laptops even though they would have been an important part of the study process.

While independent search for information requires self-directedness, it also changes some of the social aspects of having to ask for additional information. Instead of presenting his or her imperfections, the student can independently approach the question and, optimally, succeed in solving it. At best, this may foster the student's sense of autonomy. In addition, providing information in excess through various physical modalities is hardly a risk, whereas with socially mediated guidance this can often be a challenge:

> *At times the assistant may come and do the thing for you, and it would be nicer to get to do it yourself, just to take the instructions and try to get something out of it. Sometimes when you've wanted help, verbally or such, then the assistant has come and put together that instrument there and taken care of it.*
>
> *The independent work to me too is great, really... At least for me, even though group work is okay and nice but if the other person gets things faster and better, then I'm just like, the other person says well go find this and I do and I'm getting nothing about anything, --- so then you have to take responsibility for your own work and understanding too.*

Indeed, in light of this data, the role of socially mediated guidance in learning was as underlined as it was dilemmatic. By socially mediated guidance we refer to the support that the student receives in the learning process either from teachers or from fellow students. While the students appreciated the space and freedom to process things themselves and be independently responsible for their progress in the chemistry tasks, they felt a strong need for reassurance that they are progressing in the right direction. Many students emphasized the importance of receiving social confirmation and affirmation for their assumptions either from their peers or from the teacher.

5.1.2 The volitional nature of the study activities

Finally, when asked about the meaning of the physical environment in their studies, throughout the data many of the students mentioned how being able to practice in the actual laboratory brought a sense of meaning and purpose to their studies. The activities performed in the laboratory demonstrated why they were there in the first place, what they would be doing in the future, and why they should proceed and advance in their studies:

> *Here the students are doing their work and the assistants are only there to see that nothing particular is happening. In the future if you're working in the laboratory, there will probably be no one telling you to "do this, do this". Instead, you have to use your own head when you're working there, and here you get to practice that.*
>
> *For me too, with this instrumentation that I've never got to use before, it is a fine feeling of 'hey this is how it works'; there are levers and tubes and glass and all kinds of things gathered there. It is awfully great to get to use things that you never have before. And overall, the engagement of the laboratory work, that feeling when you've actually succeeded, you have that aspirin weighed, measured, everything checked – that feeling: yes I've accomplished something today! Even though it's nothing bigger than some ten grams of aspirin, still.*

As was clearly manifested in the students' reports, the physical spaces and tools enabled study processes that were highly valued by the students and appeared to strengthen not only the sense of autonomy but also competence and relatedness to their professional community.

5.2 Competence

5.2.1 The importance of practical conditions on intellectual and emotional functioning: Ergonomics, usability and the fluency of the activity in the physical environment

In a study context the need to be able to perform and accomplish tasks is accentuated. A predominant feature of a chemistry laboratory as a study context is that it involves concrete activities with physical equipment and tools. When asked about helpful and challenging aspects of the physical learning environment, the students brought up the importance of ergonomics in the laboratory settings. They

mentioned how their work can be significantly disturbed by challenging external conditions, for example, when they have to work in unergonomic positions. This was evident in the experience of a student who reported having at times to do his laboratory work "*in a highly confined space in a fetus-like position.*"

With that example in mind, one may recognize how the physical environment may have a fundamental effect in hindering or disturbing the student in applying his competence to the task at hand. The questions of usability were equally important regarding modern tools such as technological devices and software. If the prerequisites for accomplishing a task are not taken care of and the environment does not provide the needed procedural facilitation, the student cannot experience him- or herself as competent in the given physical environment. In consequence, these kinds of external factors may lower the internal sense of competence; the functionality of the physical environment may not only have an enabling role with regard to the concrete activity, but there is an essentially emotional component to this as well. Equipment and tools, traditional or modern, a chair or a smartphone, may hinder one's experienced competence but also elevate it and take it to the next level.

5.2.2 The physical environment and tools: tangible indications of competence and sources of engagement

On the other hand, the students frequently brought up that proper and well-functioning practical tools offered them a concrete indication of competence and accomplishment as well as a source of engagement in the learning process:

> *I do like it that with the kind of proper practical tools one can practice making real things, that it's not just all on the pages of the books, that it motivates and in my opinion grows that confidence, hey I could do this, hey this resulted in such a good yield. For me, that inspires me to go forward in the studies.*

It appeared that at best, the equipment offered stimulus for a positive, reinforcing cycle when the student was able to master, put together and utilize equipment initially experienced as strange and intimidating due to its complexity and sophistication:

> *To me, successful reactions or syntheses help me greatly [to engage in learning]. And special and new equipment too, that you get to familiarize yourself a little with, you wonder what to do with them and they look completely strange, and you have absolutely no clue what to do with them. And then someone clears that up for you and you're like "Aah okay!" It is so nice! ... Especially when putting together the distillation apparatus for the first time, it was absolutely horrible, and such an awful chaos! But now that you've done a fair amount of that, you're, well… it is wonderful to notice that it doesn't take 15 minutes of agonizing anymore, you take the right instruments almost automatically.*

In these cases the elements of the physical environment that used to communicate strangeness became familiar and meaningful. Instead of communicating difficulty and incapability, they offered a sense of mastery as well as an indication of progress in the learning process. More broadly, the mere observation that with time and practice the student could navigate and function in an environment that in the beginning had been fairly demanding may also be seen as a positive indicator of the learning process and the development of competence in the context. This kind of feedback on one's abilities, stemming from the mundane concrete doings in the laboratory and involving both the cognitive and the emotional dimension, may be seen to be functional in nature as it is not given by someone else but emerges through the experience of success in a practical task.

5.2.3 The challenges of competent functioning in the complex physical environment: Providing cognitive structuring and procedural facilitation in the space itself

In order to successfully function in the laboratory environment, the students need to not only have the appropriate theoretical grounding and understanding of the phenomena, but they also need to familiarize

themselves with the social practices of applying the information in practice in a given field. This is not straightforward as the shared practices are often in the form of an expert's silent information, which can be best assimilated by participating in the actual procedures and operations, or by becoming part of the professional community. This, however, may be challenging as the time spent in the actual laboratory setting is limited.

Many students reported feeling that they were expected to be more competent in laboratory work than their actual level of competence was. The laboratory environment was highly complex and demanding for them to begin with. For example, the students mentioned that watching a security video once does not necessarily mean that they have assimilated the information and would be able to take the crucial points into account when working in the laboratory setting. This, for many students, resulted in recurrent uncertainty and pondering over safety issues:

> *In theory you do know these things since you've studied the course on safe work in the laboratory, but then when you come to strange circumstances like these, it may happen that that part of your brain is not working, and you're like, there's all the rest of the hustle and bustle and the poisons there.*

In terms of the theory of flow (Csíkszentmihályi, 1988; see also Inkinen et al., 2013), if the challenges of the task are considerably higher than the students' abilities to respond to them, the students are at risk of experiencing predominantly worry and anxiety, which does not facilitate their learning or well-being. If students are frequently experiencing failure and inability with regard to the expectations rather than meeting the expectations and noticing progress in their learning, the students' sense of competence in the given physical environment may be hindered. The more complex the activity and the environment, the more cognitive structuring is needed. As mentioned earlier in the text, by physical means this scaffolding can be provided e.g. by adding tags, signs and information boards as well as paying attention to the overall clarity of the physical environment.

5.3 Relatedness

Within research on learning, relatedness has mainly been studied in relation to a given social community, such as a professional community, instructors or peer students. Although feelings of relatedness may not be connected to the mere physical surroundings, we considered it important to study the role of the physical environment from the viewpoint of an emerging sense of relatedness to a professional community. More specifically, based on the analysis, it appeared that the students referred to the role of the physical environment as part of their experiences of belonging to given physical premises or the lack of belonging. Therefore, in the following we will also use the notion of belonging when approaching questions of relatedness with regard to the physical environment.

While the dimensions of autonomy and competence were particularly central in the interview data, experiences of relatedness were less prevalent, which seems to be an important observation since within the field of chemistry there seems to be a challenge with regard to students' commitment to their studies and to the professional field.

As the students described their relation to the physical space, two central themes became relevant. Firstly, the students perceived different kinds of study activities to belong to different physical surroundings and associated a certain value to them. Secondly, as elaborated earlier, how the physical environment accommodates the activities expected to be performed in it has importance with regard to the emerging sense of competence. Consequently, the study activity, be it fluent or laborious, contributes to how easy or difficult it is for the students to proceed and succeed in their study tasks and influences how the students view themselves when working in that particular environment. In a broader sense, this bears relevance to their developing sense of relatedness to the professional field. In the field of chemistry, the laboratory surroundings are an especially central if not inseparable feature of the work itself, and therefore chemistry

offers an intriguing terrain for studying the role of the physical environment with regard to a broader formation of relatedness. In the following we will discuss each of these points in more detail.

5.3.1 From hallways to lecture rooms: Spaces of status, ownership and functionality

With regard to physical space and the sense of relatedness, for the students it was important to have certain physical spaces as anchors for their activities so that they could repeatedly utilize certain spaces instead of floating around without a "home" for their activities. When asked about their preferred study environments, the students seemed to experience most ownership and belonging with regard to spaces where the activity is not instructed but rather informal, such as the tables and chairs in the hallways, libraries, the student union room and, obviously, home, that is, spaces which the students were able to enter and use on their own and where the role of teacher was not as predominant. In fact, the spaces in which the students seemed to experience belonging often were also such that supported the students' sense of autonomy, both with regard to being able to choose and enter the space rather freely and self-directedly, as well as to the nature of the activity taking place in the space. Indeed, just the very fact of being able to choose between differentiable and flexible spaces in order to best accommodate the given study activity may be seen as supporting students' sense of autonomy and their active role in guiding their own learning process.

While most of the spaces utilized by the students were not officially designated for any specific task, the students nevertheless seemed to have a clear vision regarding which spaces they would use for which study activity. For informal tasks, such as group work, the students reported choosing mainly informal environments, such as university hallways, cafeterias or public transportation. The faculty library or classrooms, instead, were perceived as natural venues for pursuing more serious and ambitious studying.

Further, the students associated a certain value with certain study environments. Some students seemed to regard as "proper learning" those study activities that were situated in formal learning environments. For pursuing "serious study activities," students reported choosing formal study environments, such as the faculty library. The laboratory environment, clearly being a formal learning environment, was regarded as an environment where serious study activity and "proper learning" takes place. In contrast, the activities conducted in informal environments, such as group assignments, were not described as worthy and official, albeit that these study activities may be highly essential in the process of learning. In fact, based on the students' reports, collaborative study activities were not recognized as learning as clearly as individual work, either when instructed by a teacher or accomplished alone.

Specifically with regard to the laboratory environment and the related sense of belonging, some of the students indicated that in their experiences the laboratory space is not a space that belongs to them in the first place. Rather, many students perceived themselves as visitors in this space that is occupied by others, such as teachers, more advanced students and the researchers who are its main users.

5.3.2 Welcoming, functional and dysfunctional spaces: Allowing users to be human

The issue of belonging may also be seen as related to how the space communicates with work and tasks. Thus questions of usability become relevant: The dysfunctionality or impracticality of the environment does not support experiences of one or one's work belonging in the given space. The space can be seen as inviting or welcoming in relation to the individual's own functioning; for instance, how the space is designed to meet the ergonomic needs of users builds experiences of fluency vs. laboriousness:

> *Maybe the most important thing in interior design would be functionality, as you have people of different sizes, the adjustability of the surroundings, so that the work would be ergonomic. If you have to reach something from high above, that you would have some tool or a strategy, whatever it is, so that you can reach things from above safely. At times when you are taking those poisons from somewhere terribly high, me too, a small person, it is a bit like, will it come down and will my hand slip…*

If the environment is predominantly uncomfortable and performing tasks in it is cumbersome, this does not enhance the experience of being capable or, more broadly, belonging to function in that space:

> *Sometimes you kind of know what you're doing or what you'd like to do, but somehow you can't as the instrument…or the practicalities don't always work. There is no space or there are too many flies in the ointment to be able to do a simple thing.*
>
> *If you're working in a fume cupboard with acid solution, you need pH paper, if I do that I first pass three chairs, three buddies, I only get to the hallway there. Then I walk past devices where there are possibly people working so I have to dodge them too, and then I get to the assistants' room where there are three other people asking them something. I stretch there and I take the pH paper... At worst there are so many things in the way, to sum it up, there are many switchbacks there.*

How the space communicates with the student's needs or expectations may also stem from the way the student is able and allowed to individually customize the space and the facilities according to his or her own preferences, thus bringing about a personal touch with regard to the given physical surroundings. For instance, the student should be able to adjust the equipment to meet his or her ergonomic needs or to customize the environment to adapt to personal work habits as opposed to being forced to work in a space occupied by another person who has completely opposite habits. For example, the students had varying preferences regarding the need for clarity versus stimuli from the proximal surroundings and differed as to what point they started to feel the need to clear the space or wash the glassware. Whereas some students wished to have all their equipment immediately available and within reach, other students experienced this kind of abundance as overwhelming and chaotic, disturbing both their cognitive processing and conduction of practical tasks.

Specifically related to chemistry laboratory work, an important issue is also how the environment allows the students to be human. That is to say, at the beginning of studies it is natural to make mistakes and break glassware or other equipment by accident. The students described the importance of the policy in the faculty regulations on whether the students need to pay none of the expenses, part of them or all of them, as this influences their confidence to practice the work that they do not yet master. In a broader sense, these kinds of background factors may also have an impact on the students' perception of how effortless it is to be working in the space and whether it is meant for their work and incompleteness in the first place.

5.3.3 The challenges of forming a relationship with a space and place: Esthetics and uninviting spaces

In addition to the various subtler indications of the students' experienced relatedness either to the physical space that they inhabit, their peers or the field in general, the data also included indications of spaces experienced as actually uninviting. Some students described experiences of unpleasantness or repulsiveness, such as a space being esthetically so unsightly that it may actually have an alienating influence on the user: One student described as a freshman coming to the study premises full of enthusiasm, but considered changing the major because of the highly uninviting physical surroundings. In this case the student was never in close enough proximity to form a personal relationship with the physical study environment, as this was actually prevented by the strong initial sensation of the facilities as non-welcoming and uninviting. Thus the comfort, coziness and even the materials of the physical space are not irrelevant in the process of forming a relationship to the space and place. As another example, many students mentioned the relevance of the colors in the physical environment. They were hoping for fresh, calming colors, as opposed to mirthless or exceedingly bright colors that were felt to be jarring and almost obtrusive in the study environment.

While the possible lack of esthetic beauty or the experience of distaste may not, as such, prevent the experience of belonging to the physical surroundings within the study environment, it certainly does not improve the situation. The aforementioned aspects of pleasantness may be seen to point to matters that might, for their part, create beneficial circumstances for the experience of belonging to emerge.

5.4 Conclusions on the intertwinedness of the basic psychological needs within the context of chemistry studies: The physical environment as a gateway to a professional community and practices

Above we have considered the needs for autonomy, competence and relatedness as separate dimensions. These dimensions, however, are not detached from each other; we have held to this division for analytic purposes. Rather, as is implicit in the analysis above, the dimensions of autonomy, relatedness and competence are essentially intertwined. In the following, we will specifically explicate this intertwinedness in the studied chemistry context.

Within the light of the basic psychological needs, what at first came across in the students' reports was their relation to autonomy. Namely, they appeared to emphasize the need for self-directedness already in their first year of studies. This may derive from the fact that the laboratory as a space offered them a direct connection to their possible future job in the laboratory, and thus they were constantly mirroring their everyday laboratory chores to the expectations of the profession: an independent role in a laboratory, possibly working alone or as the only chemist on the premises. With this vision in their minds, they desired to form a similarly self-driven and independent work ethos already at the beginning of their studies.

As the profession of a chemist can be seen not only as an academic profession but also as handicraftmanship, the relation between the future profession and the novice stage courses is much closer than in many other academic fields in which the first years of studies are often mainly filled with theoretical courses. The laboratory environment represents a physical professional environment that the student is able to enter at an early stage of studies and, with practice, to increasingly master. Indeed, the students often seemed to experience that the work in the laboratory bridged the gap between the rookie and professional stages: by accomplishing their concrete study tasks in the laboratory, they were doing similar tasks as professionals, which served as a gateway to the professional practices of chemists. This advance in study practices can also be seen as progress in terms of legitimate peripheral participation (Lave & Wenger, 1991); as the students are admitted to participate in procedures in a given professional context, they become involved in the professional community and culture and its shared social practices and are able to proceed from the fringe areas of professional abilities towards more internalized and well-established professional practices and expertise. From the viewpoint of basic psychological needs, an environment that supports feelings of efficacy as well as a connection with those who convey it is most likely to promote internal motivation (Ryan, 2009). As the students experience the laboratory environment as closely representing their future workplace and mirror their actions to their future role as a professional, it is particularly important to pay attention to how the initial experiences of working as a chemist in a laboratory setting are built. Here the design of a functional and pedagogically purposeful environment becomes central.

To conclude, based on the results, we suggest that the experience of a given physical space builds through the activities performed in that space. The functionality and usability of the space and tools are highly important as they contribute to the fluency of the activity taking place, which builds the students' view of themselves acting in that given environment. When a student experiences the space as a place that involves equipment and functions that he or she can master and perceives him- or herself as someone successfully functioning in that environment, he or she is more likely to experience belonging to that environment and context. Thus, how the physical environment manages to accommodate the most mundane everyday activities may, for the users, build on a broader experience of relatedness. This may be of importance when building a professional identity and creating a sense of belonging to a professional community. Thus, by providing sufficient or even optimal premises for study activities, the physical environment may facilitate this process to varying degrees.

Table 1

Summary of results

Conclusion	Examples from the data	Practical implications
Physically mediated guidance and the use of modern technological devices may support students' sense of autonomy and competence.	Students were hoping for clear, well-structured spaces, where the basic-level information may be implemented in the space, or the students can acquire it with the help of technological devices, in order to enable them to navigate and function in the space in a self-directed manner. Socially mediated guidance was regarded as important in confirming one's assumptions, in a facilitating rather that instructing manner.	It is important to distinguish between physically and socially mediated guidance and their purposeful roles. Physically mediated guidance should be more widely acknowledged and utilized in communicating information on a basic level, such as where to find needed equipment or dispose of substances, whereas social guidance is needed in the more complex cognitive processing.
The physical environment may complement the students' existing competence and offer procedural facilitation for their learning processes.	The chemistry laboratory as a new and complex working environment seemed to be highly challenging, if not intimidating for the students at first. However, if the students were able to successfully enter and learn to master the equipment and the space, it offered them fruitful and highly engaging learning experiences.	Students should be provided with suitable spaces and tools as well as sufficient guidance in using them in order to ensure the scaffolding of the learning processes by both physical and social means. The more complex the activity and the environment, the more cognitive structuring is needed.
Being able to utilize diverse learning environments in a self-directed manner may support students' sense of autonomy in directing and regulating their own learning process.	The students associated certain study activities as well as a certain value, status and ownership to different learning environments. Formal learning environments, such as lecture halls, libraries and laboratories, as well as the formal and focused learning activities occurring in them, were often perceived as more "proper" than the informal and collaborative learning environments and activities, even though the latter were experienced as crucial in the learning process.	Flexible, diverse and freely accessible spaces should be available for students in order to accommodate the variety of study activities as well as support students' sense of autonomy and relatedness. Informal environments may promote more sense of belonging and ownership in novice students; the possibility to act in a professional work environment may bridge the gap between the rookie and professional stages and also bring a sense of meaning and purpose to the studies.
The functionality of the physical environment contributes to the cognitive processes of the users as well as to the related emotional experience of oneself acting in the given environment. Consequently, the physical environment may be instrumental in the development of the students' sense of relatedness to the professional community.	For the students the laboratory strongly represented their future work environment as chemists, and the experiences occurring in it were frequently mirrored to their future professional identity. The functionality of the physical environment and the fluency of the activity appeared to contribute to students' sense of belonging to the professional context.	Special attention should be paid to the functionality of the physical environment as well as the fluency of short periods of practical work, as the experience of a physical environment builds through the activity performed in the environment.

6. Discussion

In this study we analyzed the role of the physical environment in learning and well-being from the viewpoint of self-determination theory and basic psychological needs. The physical environment may support not only learning and well-being, but also autonomy, competence and relatedness with regard to the learning environment and the professional field. In the following we will elaborate on the broader theoretical and practical implications of the results.

The physical space and tools can be seen as facilitating or posing a challenge to study activities and cognitive functioning by various means. The physical environment not only influences the cognitive learning process but inevitably gives rise to an emotional experience, as well. For instance, if the physical environment poses a challenge to study activities, and because of this the students constantly feel incompetent in the learning context, this experience builds on their views of themselves acting in that particular environment, and consequently, they may be less likely to frequently and willingly approach the same environment in the future. Moreover, in order to reduce unnecessary anxiety over tough challenges with regard to their existing abilities, as well as to provide optimal grounds for learning to occur, it would be important to complement the students' existing competence by offering procedural facilitation and support in both the physical and social environment. The emotional experience resulting from the concrete activities taking place in the physical space can support committing to that particular working environment, as well as the broader context related to it, such as the professional community of chemists.

Recent pedagogical research has emphasized the emotional components of the learning process, such as interest and engagement (see e.g. Csíkszentmihályi, 2014; Heikkilä, Niemivirta, Nieminen & Lonka, 2011; Hidi & Renninger, 2006; Inkinen et al., 2013; Lonka 2012; Lonka & Ketonen 2012), as opposed to more traditional views concerning merely cognitive aspects of learning. Furthermore, engagement in learning has been approached through conceptualizing cyclical stages in the learning process and defining optimal practices. We want to shed light on the role of the physical environment in the learning process: how the physical environment may support or hinder learning practices, and how that, in turn, contributes to the emotional experience and sense of commitment or the lack of it. This broadened viewpoint involving the role of the physical environment in learning may be utilized in envisioning a more holistic approach to engaging learning. The functionality and usability of the space and the equipment, the guidance implemented in the space as well as other support available (peers, teacher) all play key roles in the learning process.

From the viewpoint of self-determination theory, physical environment represents a novel context for the application of the theory. Based on this study, similarly to social and cultural environment, physical environment can also support or thwart the fulfillment of the basic psychological needs. Furthermore, this study raises theoretical questions concerning the role of the three basic psychological needs as well as their interrelations in different contexts. While the fulfillment of all three needs is essential, within the light of these data it strongly appeared that in a study context, perhaps similar to other contexts that are highly demanding in relation to existing abilities, the dimension of competence seemed to be very central, if not a prerequisite, for experiences of autonomy or belonging to emerge. For example, it is challenging for students to develop a sense of belonging to the professional community if they mostly feel incapable of performing basic tasks and thus find themselves incompetent in the field in general. While the developers of the theory strongly emphasize the importance of all three needs as well as the synergy between them, depending on the nature of the activity, relatedness, for instance, may at times be less central to intrinsic motivation than autonomy and competence (Deci & Ryan, 2000). On the other hand, in other occasions, such as with children or adolescents who are at risk of dropping out of school, it may be most crucial to support the experience of relatedness (E. Deci, personal communication with the first author, October 28, 2014).

Furthermore, it has been acknowledged that the dimensions of competence, autonomy and relatedness are strongly interrelated, and for instance, an autonomy-supporting atmosphere will assist in promoting relatedness and competence as well (Deci & Ryan, 1987; Wolters & Gonzalez, 2008). Acknowledging these previously researched viewpoints, we wish to both emphasize the importance of

promoting the fulfillment of all three basic needs in the learning context as well as further examine their interrelations and prerequisites. In our view the three dimensions may not in all contexts be equally interrelated and in identical interaction with each other. Instead, they may be interdependent or sequential depending on the context. This context-driven analysis of the underlying dynamics may be an intriguing terrain for further research on the theory. What is of particular interest in the field of higher education is how the basic psychological needs interact with vital study-related phenomena such as the commitment to studies and the development of professional identity, and how to best take this into account when designing learning processes.

This study demonstrates the importance of the physical environment for intellectual as well as emotional functioning. The intellectual functioning of an individual is always nested in a given physical environment, even when the work is carried out in a virtual environment. In fact, it may be that the impact of the physical environment on psychological functioning is often highly underestimated. With regard to future research it would be intriguing to untangle the effects that different physical space solutions have on human functioning. It is likely to make a difference whether one is working in a familiar workspace or in increasingly common open-plan multispace offices, not only with regard to ergonomics but also with regard to experiences of belonging or recovery. For instance, experiences of ownership and relatedness or beneficial, uplifting and inspiring mental modes can be supported by various means in both stable and mobile offices. In addition to the focal social aspects such as the shared culture of the community, some physically mediated options might include customizing the physical space with personal items but also utilizing modern and mobile technological means, such as customized technological tools or screen savers. Moreover, the bodily dimensions of office environments beyond ergonomics offer an intriguing aspect to the psychophysical experience. For instance, the possibilities that the spaces or furniture offer for varied bodily postures and physical movement all contribute not just to physical health but also to the psychological experience and functioning.

To conclude, it is essential to utilize psychological and pedagogical knowledge when designing work and learning environments. By considering the interplay between the material world and human functioning, we can create fruitful ground for thriving users and develop novel design for leading university campuses and other indoor environments.

Keypoints

- Similarly to social and cultural environment, physical environment can also support or thwart the fulfillment of the basic psychological needs. Learning and wellbeing can be facilitated by developing physical environments that support the basic psychological needs.
- The physical environment contributes to the cognitive functioning of the users as well as to the related emotional experience of oneself acting in the given environment. For example, a well-structured physical environment may offer physically mediated guidance, cognitive structuring and procedural facilitation for the students' learning processes. It may complement the students' existing competence and scaffold the students' sense of control in situations where the challenge of the task is experienced as high.
- Physical spaces and tools should be utilized in offering students functional feedback, engaging learning experiences and gateways to practicing their future profession. In order to support the basic psychological needs as well as help the students to regulate their own learning process the students should be provided with suitable spaces and tools as well as sufficient guidance and autonomy in using them. Special attention should be paid to the functionality of the physical environment, as the experience of a physical environment builds through the activity performed in the environment.

- The results provide both theoretical and practical value in understanding the role of the physical environment as part of human functioning and serve as an opening to a previously unexplored ground. By bringing together the theoretical approaches of socially and physically distributed intelligence and research on motivation, this study demonstrates the importance of the physical environment for intellectual as well as emotional functioning. The intellectual functioning of an individual is always nested in a given physical environment, even when the work is carried out in a virtual environment. Utilizing psychological and pedagogical knowledge is essential when designing or renovating work and learning environments in order to fully make use of the potential of physical environments as part of human performance.

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